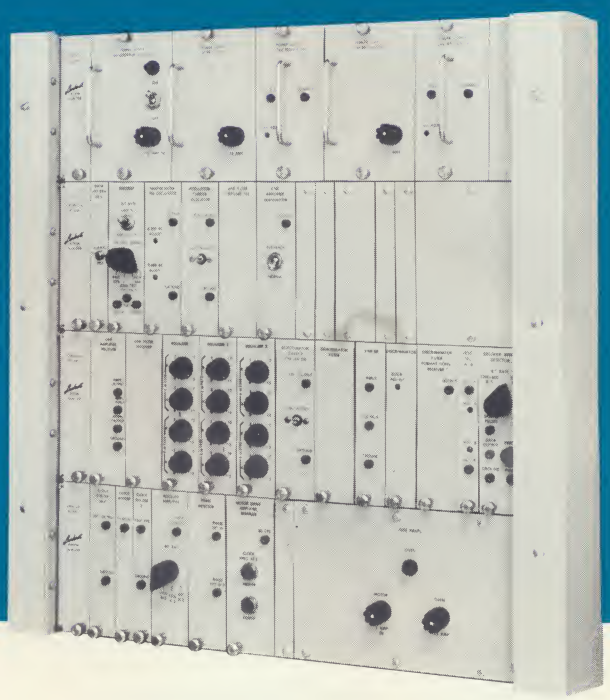
Lenkurt®

26B

DUOBINARY-DATATEL™ data modem

The 26B Data Modem offers a highly accurate means of transmitting serialized digital data over standard 3-kilocycle voice channels derived on cable, open-wire, or microwave radio systems. Transmission speeds of over 2400 bits-per second (bps) — double the ordinary speeds — are achieved with Lenkurt's new Duobinary coding technique. Automatic detection plus an extremely low error rate are bonus features of Duobinary coding. Conventional data speeds of 600 and 1200 bps are attained by proven binary FM methods.

The 26B performs efficiently as a transmission link for computers and other types of digital communications.



BANDWIDTH ECONOMY — Lenkurt's Duobinary technique doubles the data-handling capacity of an ordinary 3-kilocycle voice channel, compared to standard binary methods.

HIGH SPEED — 2400 bits per second is the normal operating speed in the Duobinary mode. Operating speeds up to 3000 bps, with slightly increased error rates, can be achieved. Standard synchronous speeds of 600 and 1200 bps are also available, along with any non-synchronous speed up to 1600 bps.

LOW ERROR RATE — Because of its low intersymbol interference at 2400 bps, the 26B has an exceptionally low error rate. When operating on a very noisy channel (16 db signal-to-noise ratio) the average error rate is only 1 bit in 10^5 at 2400 bps.

BUILT-IN ERROR DETECTION — With the Duobinary technique, binary data is encoded in such a way that the signal must follow a predetermined pattern. Thus, error detection can be accomplished by simply monitoring this pattern and without adding redundant bits.

SIMPLICITY AND RELIABILITY — Duobinary circuits are far less complex than quaternary circuits that achieve comparable speeds. This, plus solid-state design and printed circuitry throughout, makes the 26B compact and reliable. A complete duplex terminal is less than 14 inches deep and needs only 21 inches of rack space.

FLEXIBILITY — The speed versatility of the 26B makes it useful for many different data transmission applications. Modular construction permits simplex, duplex or special terminal configurations. Signal inputs and outputs meet EIA Standard RS-232-A and optional converters are available to adapt to other input and output requirements.

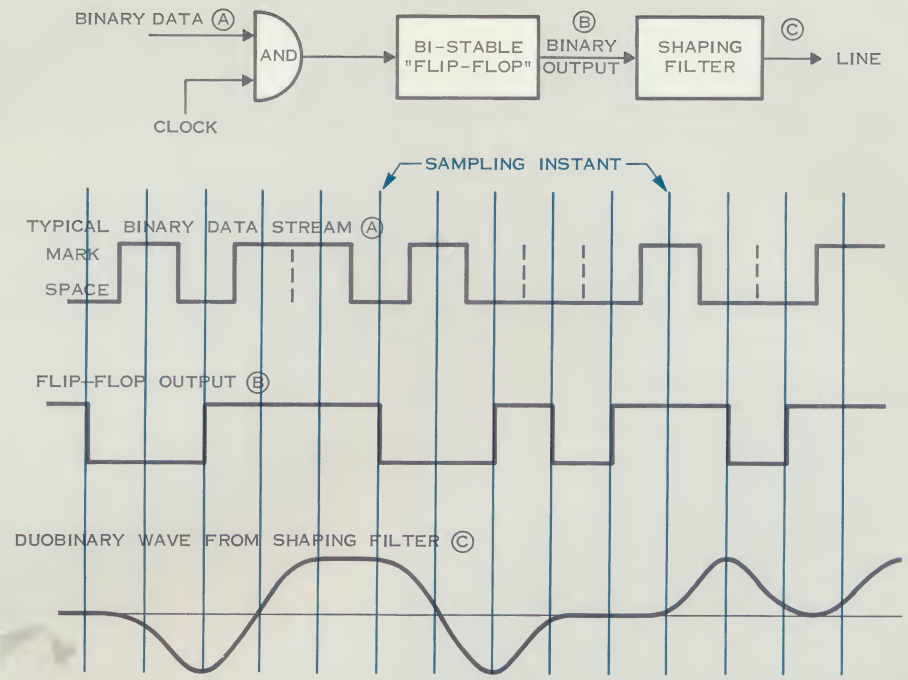


Figure 1. A typical form of the Duobinary encoder showing the special waveform resulting from the coding process. The coincidence of a clock pulse and a binary **space** causes the bistable multivibrator (flip-flop) to change its state. When the output signal of the multivibrator passes through the shaping filter, the three-level Duobinary wave results.

TYPICAL APPLICATIONS

The 26B can be used wherever economical, high-speed transmission of digital data is necessary. The basic equipment handles serial-by-bit binary data in the NRZ (non-return to zero) format.

Typically, the 26B is used for one or two-way data transfer between digital computers. Other practical applications include telemetering, digitized voice or facsimile transmission, and air-ground data communications via UHF radio link. Because of its economical use of bandwidth, the 26B can transmit data effectively at 2400 bps over transoceanic submarine cables.

THE DUOBINARY TECHNIQUE*

The Duobinary technique is a signal design process that *codes* and *shapes* conventional binary data signals into a special waveform, characterized by three voltage levels. This process results in a two-to-one bandwidth compression, thus providing twice the data capacity of ordinary binary systems.

The process of coding and shaping transforms binary "marks" and "spaces" into the three discrete voltage levels. Both the upper and lower voltage levels represent "marks," while the center level represents "spaces." The Duobinary signal differs from an ordinary three-level (or ternary) signal in that the particular voltage level (upper or lower) occupied by each "mark" does not occur randomly, but is determined, instead, by a strict encoding pattern. As a consequence of predetermining the position of each "mark," the bandwidth required for transmission is reduced by one-half when compared to binary systems.

As a bonus, the Duobinary technique features built-in error detection. Consequently, there is no need to add redundant information digits, as required to detect errors in conventional data systems. In addition, the Duobinary technique provides the speed of the older quaternary system, plus superior accuracy and less complex circuitry — no more than required in the earlier binary systems.

*(Reference *The Lenkurt Demodulator*, February, 1963)

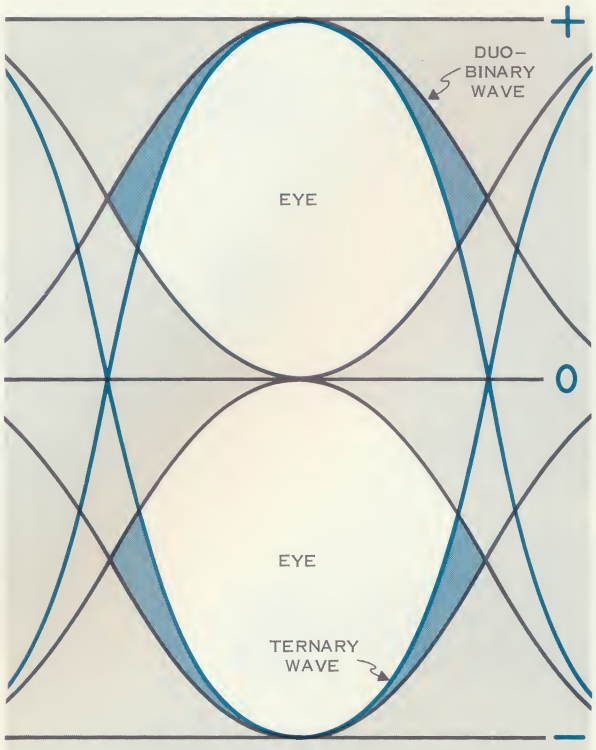


Figure 2. Eye pattern of conventional ternary signal (blue) compared to eye pattern of Duobinary signal. The blue-tinted eye area is lost by the ternary signal because it is allowed to traverse from one extreme level to another. Lost area increases inter-symbol interference, thus making the ternary signal more vulnerable to noise and increasing error rate.

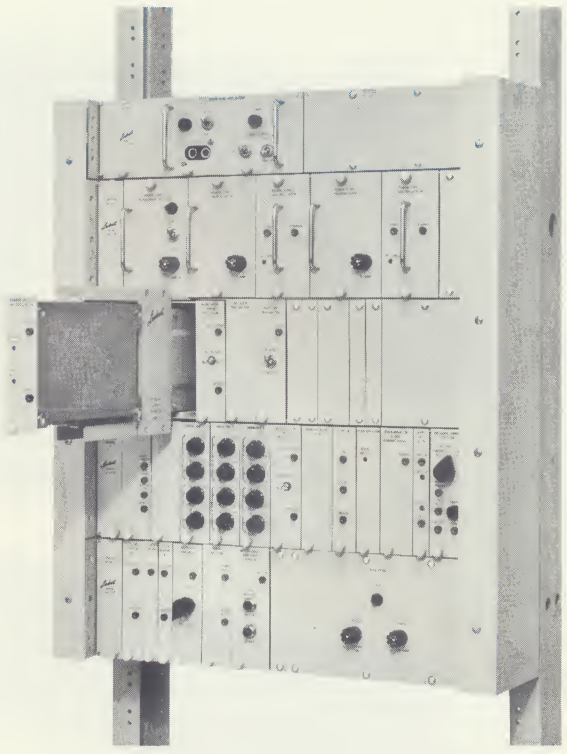


Figure 3. Using the special **extender,** demonstrated in this figure, plug-in units may be pulled out from the panel for checkout and testing while in actual operation.

INPUT AND OUTPUT CONSIDERATIONS

The 26B accepts serial-by-bit binary data in the NRZ format, with signal levels and impedance characteristics in accordance with EIA standard RS-232-A. Four input voltage level options and two output options are available by strapping the appropriate terminals. These options are listed in the Technical Summary. Even greater flexibility is possible with custom-designed plug-in interface format converters that match input and output requirements specified by the user.

TERMINAL EQUIPMENT

For maximum flexibility and convenience to the user, the 26B consists of plug-in units that are modular by function. Thus, each 26B can meet the exact functional requirements of any data transmission system. The most common terminal configurations are duplex, simplex-transmit, and simplex-receive. A number of options are available such as clock sources, format converters, order wire and alarm circuits, equalizers, and power supplies, each as a plug-in module.

High reliability and minimum maintenance are assured with the use of advanced solid-state design and printed circuits. In addition, the 26B contains heavy-duty industrial and military grade components employed considerably below their rated capacity. All commonly used test points, controls, and interface connections are accessible from the front of the equipment. A built-in data pattern generator provides random binary data for testing and alignment, and an error detector monitors transmission quality. The only service instruments required are standard oscilloscope, a VTVM, and a frequency counter. Mean-time-to-repair a failure is less than 15 minutes.

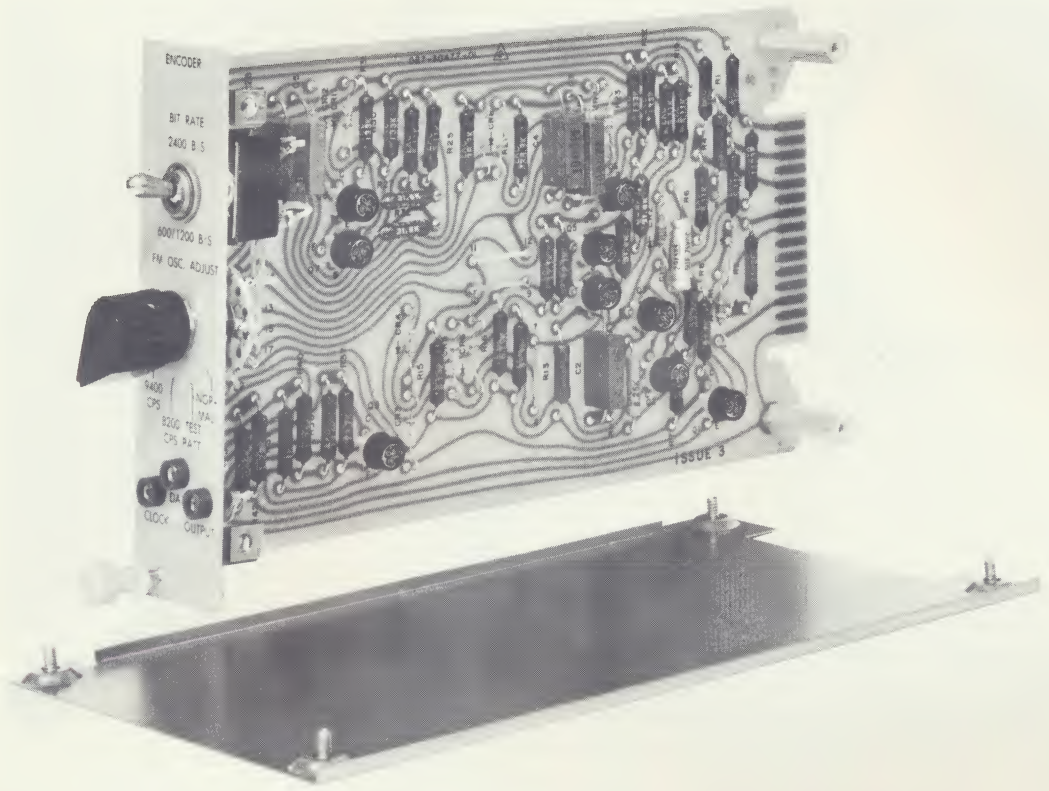


Figure 4. Typical modular plug-in unit with protective side cover removed exposing compact and sturdy construction. Note that all test points and controls are on the front panel of the unit.

TERMINAL OPERATION

Transmitter Section The serial-by-bit data input to the modem is converted in the transmitting section to the binary pattern that is best suited for the bit rate to be used. The Duobinary mode is used for bit rates of 2400 bps and higher, while the binary mode is used for speeds of 1600 bps and lower. In the 2400 bps Duobinary mode, the data is encoded using either an internal or external clock. (This transmit clock is not required in the binary mode.) The encoded binary data is next put through a low-pass shaping filter and is then used to control the frequency of a voltage-controlled FM oscillator.

In the binary mode, a binary ONE is represented by one line frequency, and a binary ZERO by another. In the Duobinary mode, either the lowest or the highest line frequency represents binary ONE, depending on the previous data pattern. Binary ZERO is represented by the *mean* value of the two frequencies.

A modulator stage, followed by a lowpass filter, translates the FM oscillator output to the voice frequency range. The signal is then amplified and coupled to the transmission line.

Receiver Section At the receive terminal, band-limited FM signals are fed through an input filter and a set of adjustable delay and amplitude equalizers to the receive-line amplifier. The amplified signal is demodulated to the original FM spectrum, filtered, and then passed through a two-stage limiter which provides a constant amplitude signal for the discriminator. The discriminator converts the FM signal into an analog voltage which is fed through the discriminator filter to the level selectors. (Two level selectors are used in the Duobinary mode, and one in the binary.) The signals are then fed into the decoder where they are converted back to their original binary form.

When operating in the Duobinary mode, the outputs of the two level selectors are also fed into the error detector along with the receive clock signal. The error detector monitors the Duobinary coding pattern for violations caused by disturbances in the transmission path. Whenever a pattern violation occurs, an error pulse is generated which lights the ERRORS lamp on the front panel. The error pulse is also fed to the output of the receiver section where it can be used for an external alarm or for error counting. The use of an internal receive clock to provide error detection is optional.

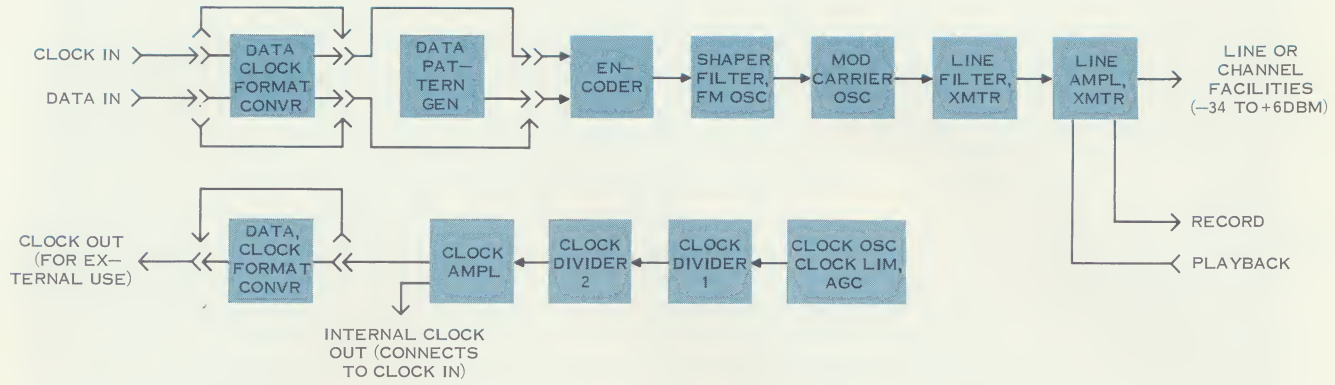


Figure 5. Block diagram of Transmitter Shelf equipped with optional transmit clock.

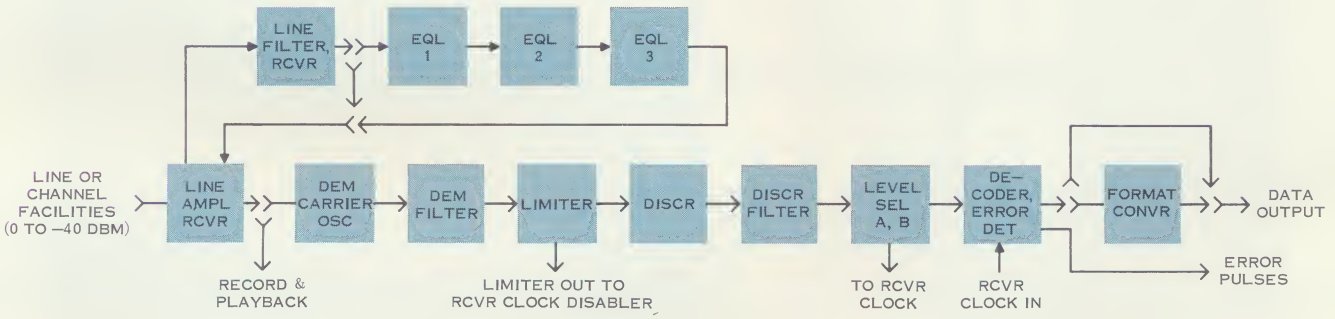


Figure 6. Block diagram of Receiver Shelf 1.

TIMING SOURCES

A transmit clock is required for the 26B when operated in the 2400 bps Duobinary mode. A number of options are available. Lenkurt can supply plug-in type clocks that provide outputs with a stability of ±5 parts in 100 million for one hour. External clocks can be used provided they meet the frequency stability requirements. (Any external transmit clock must be more stable than the clock used at the receiver.) Custom-designed interface converters can be supplied if the external clock signal does not meet requirements.

A receive clock is not required except when necessary to retime received data, or when the Duobinary error detector is used. Lenkurt has available three plug-in type clocks. The first is an internal source tuned-circuit clock with a stability of 100 parts in 1 million for one hour. The second is an internal source crystal-controlled clock with a stability of 5 parts in 100 million for one hour. The third clock can be used with an external timing source if the source has a stability of 5 parts in 100 million for one hour. This clock incorporates a data synchronizer for read-out of data in phase with the external clock.

PERFORMANCE CONSIDERATIONS

The 26B is capable of operating over typical FCC Tariff 237 Schedule 4A telephone network facilities and other voice-frequency transmission facilities which meet the line requirements listed in the Technical Summary. The 26B conforms to applicable portions of EIA Standard RS-232-A and meets the requirements of good communications practices with respect to transmission levels, balance and reliability. Normal subscriber station protection devices can be used with the equipment.

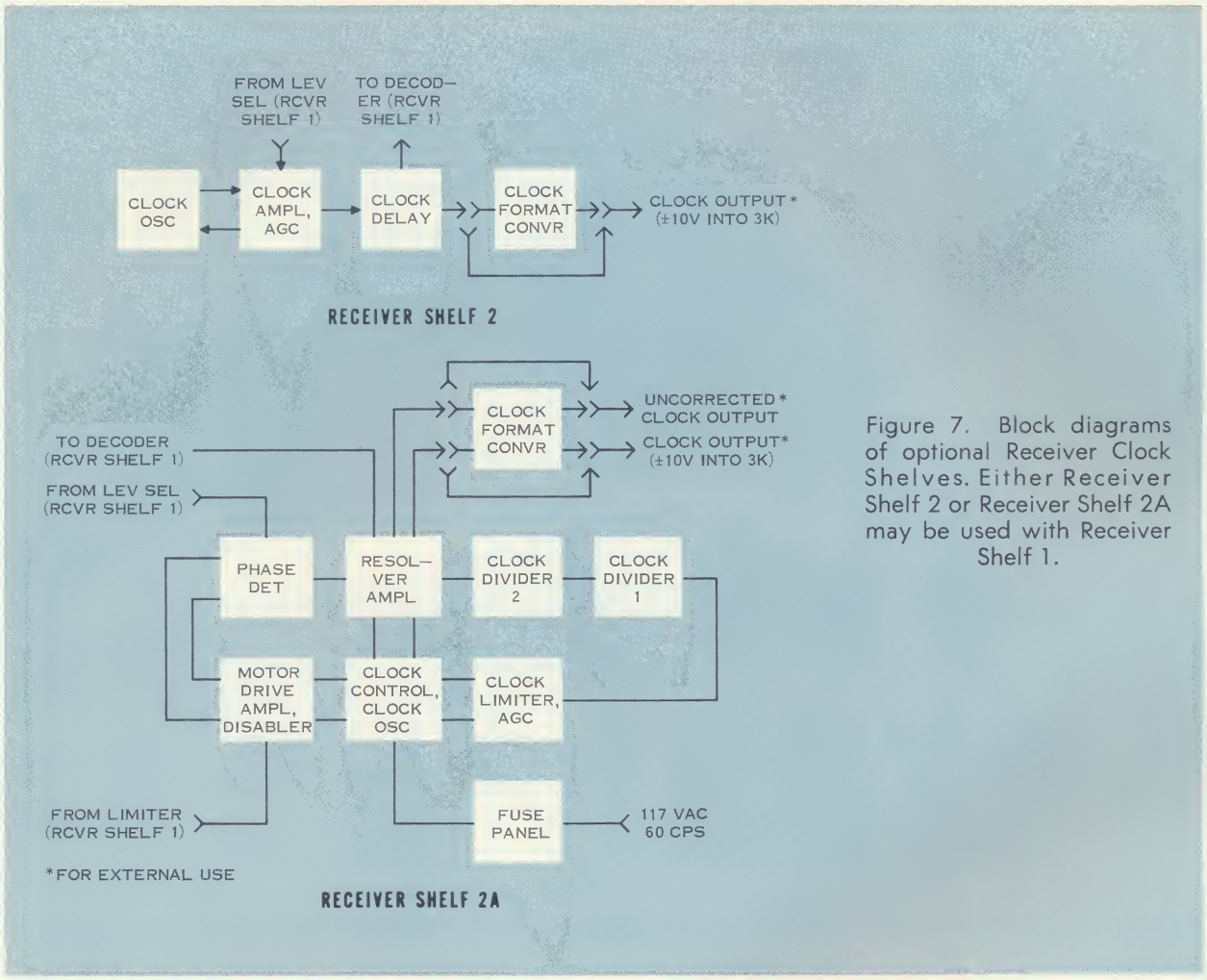


Figure 7. Block diagrams of optional Receiver Clock Shelves. Either Receiver Shelf 2 or Receiver Shelf 2A may be used with Receiver Shelf 1.

EQUALIZING EQUIPMENT

Error rates in data transmission are minimized when delay and amplitude distortion, introduced by the characteristics of the transmission line, are reduced or eliminated. As an optional feature, the 26B receiving equipment can be supplied with a delay equalizer consisting of three variable, plug-in modules. Each equalizer module has two sets of front panel controls, providing a total of six corrective sections separated by amplifier stages.

In addition, an optional delay/amplitude equalizer shelf is available which incorporates a power supply, two line amplifiers, and 6 additional plug-in type equalizers. It is used when more than one incoming line must be equalized, or where more than one set of equalizers are needed.

ORDER WIRE AND ALARM PROVISIONS

Supervisory voice communication between 26B terminals is made possible by an optional order wire and alarm shelf. This shelf includes an alarm function that activates a visual and audible signal when the data signal is interrupted or falls 20 db below the adjusted incoming line level. A Data/Talk switch selects the line function and activates the alarm at both terminals when placed in the TALK position. A standard telephone headset or handset can be plugged into the front panel of the module.

POWER SUPPLY

For highest performance, a regulated power supply is provided with each 26B. Consisting of five plug-in modules, it furnishes ±24VDC power which is regulated for high system stability. This power supply can tolerate 30-volt step-function power line transients without losing regulation. It has sufficient capacity for a complete duplex terminal with ample reserve for accessory equipment.

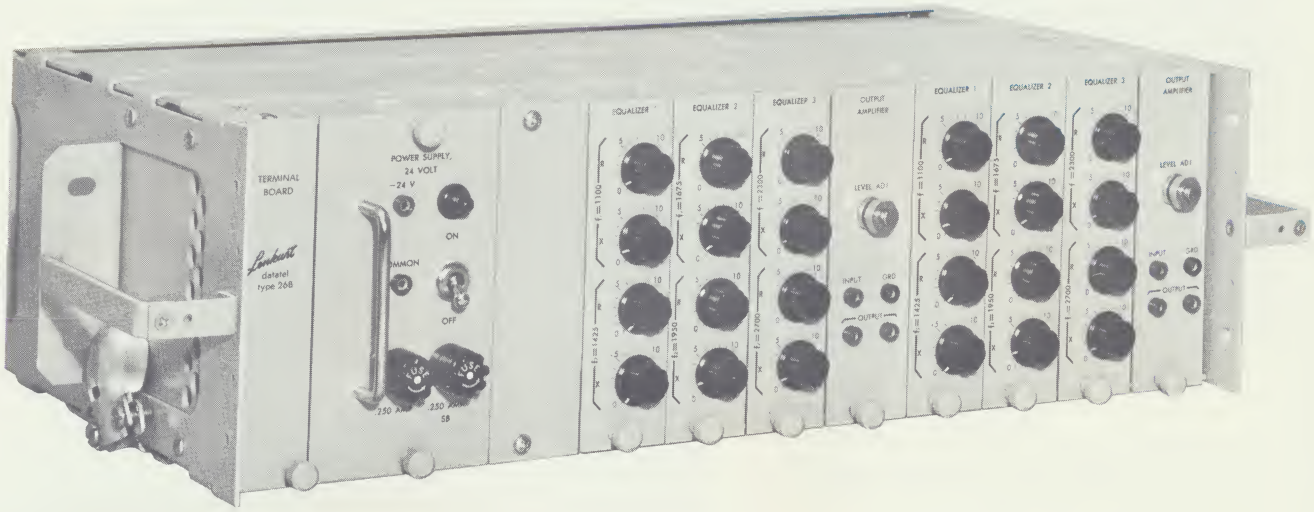


Figure 8. Optional Delay Equalizer Shelf provides signal level adjustments, delay and amplitude equalization, and amplification of the equalized signals.

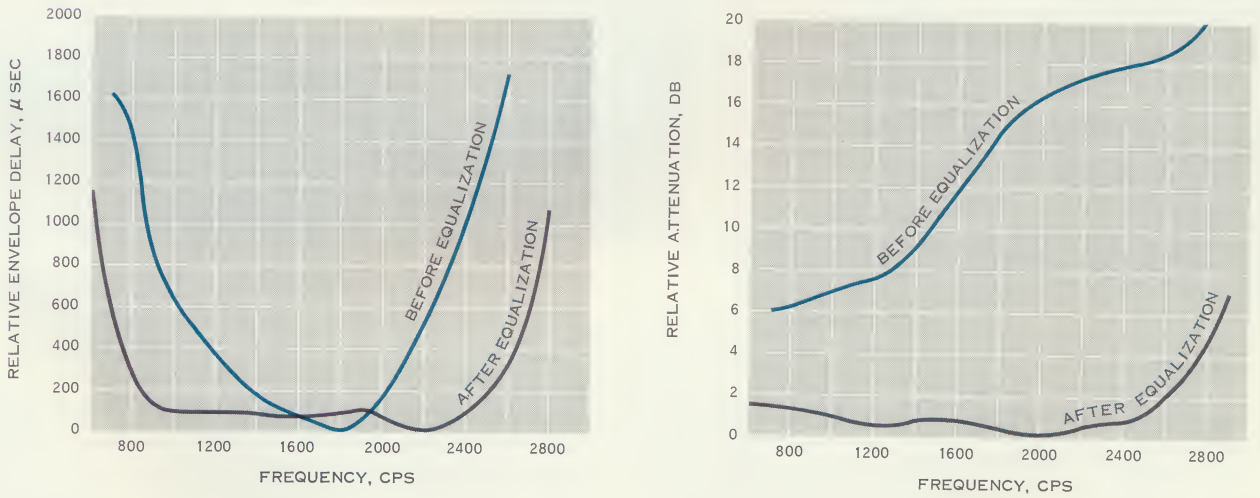


Figure 9. (A) Typical envelope delay characteristics and (B) typical attenuation characteristics showing the signal improvement resulting through use of Delay Equalizer Shelf.

TECHNICAL SUMMARY

DATA RATES

Fixed	Nominal 2400, 1200 or 600 bps
Variable	Up to 1600 bps in binary mode and up to 3000 bps in Duobinary mode.

DIGITAL DATA INPUTS

Input Lines	Single wire, ground return
Format	NRZ serial-by-bit binary data
Amplitude	EIA Standard, ±3 to ±20 volts (other voltage options available). Rise/fall times up to 25 μsec. are acceptable
Input Impedance	5000 ohms (approx.)

SIGNAL OUTPUT TO LINE (Transmitter)

Output Signal	FM
Frequency Range	1100 to 2300 cps
Output Level	Adjustable, −34 to +6 dbm
Output Impedance	600 ohms, balanced

SIGNAL INPUT FROM LINE (Receiver)

Input Signal	FM
Frequency Range	1100 to 2300 cps
Input Level	−40 to 0 dbm (−10 dbm nominal). Short-term variations 10 db above and 20 db below the −10 dbm line up signal level are acceptable.

DIGITAL DATA OUTPUTS

Output Line	Single wire, ground return
Format	NRZ serial-by-bit binary data
Amplitude	±10 volts into 3000 ohms resistive load (other voltage options available). Rise/fall times are 1.0 μsec. max.

DIGITAL DATA VOLTAGE LEVEL OPTIONS

Input Options	*Logic One*	*Logic Zero*
1	−20V to +0.5V	+3.0V to +20V
2	−20V to −3.0V	−0.5V to +20V
3	+20V to +3.0V	+0.5V to −20V
4	+20V to −0.5V	−3.0V to −20V

Output Options	*Logic One*	*Logic Zero*
1	−10.0V	+10.0V
2	+10.0V	−10.0V

TRANSMITTER CLOCK REQUIREMENTS
(Required for fixed speed operation only)

Waveform	Square wave, positive going edges coincident with data bit transitions.
Frequency	Equal to the data input bit rate used.
Amplitude	
From External Source	6 to 40 volts (peak-to-peak) into 500 ohm load. (Other voltage options available.) Rise/fall times up to 25 μsec. are acceptable.
For External Use	±10 VDC square wave into 1000 ohm load. (Other voltage options available.) Rise/fall times are 1.0 μsec. max.

RECEIVER CLOCK SPECIFICATIONS
(Available only if received data is retimed)

Waveform	Square wave, 50% duty cycle, positive or negative edges coincide with data bit transitions.
Frequency	Equal to data bit rate and synchronized with the received data.
Amplitude	
For External Use	±10 volts into 3000 ohm resistive load. (Other voltage options available.) Rise/fall times are 1.0 μsec. max.
From External Source (If Type 2B Receive Shelf is used)	6 volts to 40 volts (peak-to-peak) square wave (50% duty cycle) into 5000 ohm load. (Other voltage options available.) Rise/fall times up to 25 μsec. are acceptable.

POWER REQUIREMENTS

Nominal AC Input	0.5 amperes at 117 VAC ±11%, 50-60 cps.

DIMENSIONS (Each functional shelf)

Height (order wire and alarm)	3½ inches
Height (other functional shelves)	5¼ inches
Width	Mounts on 19-inch rack
Depth	13½ inches

ENVIRONMENTAL CONDITIONS (Operating)

Temperature Range	0° to 50°C. (32° to 122°F.)
Relative Humidity	95% non-condensing (max.)
Altitude	To 10,000 feet

LINE REQUIREMENTS

1. *Frequency Response*	
With one set of equalizers	900 - 2700 cps, −2 db to +6 db 1000 - 2400 cps, −1 db to +3 db
Without equalization	900 - 2500 cps, ±1.0 db
2. *Envelope Delay*	With 1.7 milliseconds
With one set of equalizers	700 - 2700 cps Within 1.0 millisecond 1000 - 2400 cps
Without equalization	With 0.3 millisecond from 900 to 2500 cps
3. *Line Impedance*	600 ohms nominal at 1000 cps
4. *Line S/N Ratio**	16 db at 2400 bps 10 db at 1200 bps

* For a bit error rate of 1×10^{-5}
S — RMS Signal Power
N — RMS White (gaussian) noise power in a 3.4 kc band, flat weighting.

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